IMPACTS OF A HYDRO-ELECTRIC RESERVOIR ON POPULATIONS OF CARIBOU AND GRIZZLY BEAR IN SOUTHERN B.C.

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Impacts of a Hydro-Electric Reservoir on Populations of Caribou and Grizzly Bear in Southern British Columbia

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for the

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ABSTRACT

The impacts of a hydro-electric reservoir on populations of caribou and grizzly bear were studied north of Revelstoke, B.C. Information collected for 3 years prior to flooding was compared with data collected in 1984-85. The reservoir did not obstruct the movement of caribou and animals did not attempt crossing during periods when ice conditions were hazardous. Evidence suggested that predator avoidance was the most important determinant of habitats used in spring. The cleared reservoir was an important habitat for caribou in spring because of the abundant food and security from predators it offered. A potential decline in caribou recruitment was noted in 1985 coincident with reservoir flooding. Further data will be required to confirm this decline. Recommendations include clearing some logged areas adjacent to formerly used reservoir habitats and maintaining movement corridors of mature timber between seasonal habitats. Inconclusive evidence suggested that the reservoir was a barrier to movement for grizzlies. Grizzly spring movements were related primarily to finding good feeding sites. Avalanche paths in side drainages were the principal habitats used. Cleared areas did provide an abundance of food comparable to naturally disturbed habitats. The main impact of reservoir flooding was in shifting the habitat use of bears from relatively secure areas, in the reservoir, to high risk habitats on the highway and powerline right-of-ways. Mitigative recommendations include reducing the attractiveness of right-of-ways by planting less palatable plants and maintaining spring ranges in tributary valleys by careful development planning. Formats used for recording habitat information and summarized guidelines for identifying important caribou and grizzly spring ranges are given in the appendices.

TABLE OF CONTENTS

ABSTRACT ii

INTRODUCTION 1

METHODS 2

SECTION 1 - CARIBOU

RESULTS
Reservoir Impacts on Movements 3
Spring Habitat Use 6
Predators and Habitat Selection 8
Characteristics of Spring Habitat 10
Population Structure and Mortality 11

DISCUSSION
Movements Across the Reservoir 13
Spring Habitat Use 13
Predator Avoidance and Habitat 14
Impacts of Habitat Losses 14
Mitigative Measures 15
Identification of Priority Areas 16

SECTION 2 - GRIZZLY

RESULTS
Reservoir Impacts on Movements 19
Spring Habitat Use 19
Characteristics of Spring Habitat 24

DISCUSSION
Movements Across the Reservoir 25
Habitat Use 25
Potential Impacts 25
Behaviour and Vulnerability 26
Mitigative Measures 26

LITERATURE CITED 28

APPENDICES 30

INTRODUCTION

The impacts of hydroelectric reservoirs on populations of caribou (Rangifer tarandus) and grizzly bears (Ursus arctos) have never been studied in British Columbia. Klein (1980) showed that the main impact of man-made obstructions on northern caribou and reindeer was to block, deflect or delay their long migrations. He further speculated that artificially regulated rivers and lakes could form drowning traps for animals attempting to cross because of inward sloping ice shelves. Because of the large ranges of northern caribou, the actual reservoirs probably represent an insignificant range loss. Southern caribou, however, are seasonal, elevational migrants and do not undertake long north-south migrations annually. Prior to flooding, the caribou north of Revelstoke used the reservoir area in May each year and frequently crossed the valley while moving between seasonal ranges (Simpson et al. 1986a). The three potential impacts on caribou, which I examined in this study, were loss of spring range, restriction of movements across the reservoir and mortality from drowning in unfavourable ice conditions.

For grizzly bear, the perceived impacts were potentially less severe. Grizzlies den from November to April in the study area (Simpson et al. 1986b), so they were unlikely to cross the reservoir when ice was present. Grizzlies also used and crossed the reservoir in spring. Two of ten radio-collared bears spent time in the reservoir area, but only one regularly crossed the reservoir. The potential impacts on grizzlies, which I examined, were restriction of movements and loss of spring range.

Caribou numbers are believed to have declined in many parts of British Columbia coincident with human developments and habitat alteration. There has been controversy over how caribou numbers are reduced in developed areas. Three suspected causes have been reviewed by Bergerud (1978). These include: 1) range destruction, food shortages and starvation; 2) increased access, overhunting and poaching; and, 3) increased predation. Key causative factors have not been isolated because all three factors were changing at the same time. Differences in habitat can dramatically alter predator efficiency by making prey more or less vulnerable to predators (Bergerud et al. 1983). Habitat use data for grizzlies and caribou were used to assess how predation pressure alters habitat selection and how major habitat alterations, such as reservoir clearing and flooding, can affect predator-prey relationships.

This research was funded by the B.C. Ministry of Environment, Wildlife Branch using funds provided by B.C. Hydro and Power Authority. Under the terms of the wildlife compensation, funds were provided to obtain basic information, with which the Wildlife Branch could better manage the little known caribou and grizzly populations north of Revelstoke, B.C. I gratefully acknowledge the assistance of the Wildlife Branch and particularly the Regional Biologist, Guy Woods, in reviewing manuscripts and providing the pre-flooding data used in this report.

METHODS

Baseline information, prior to the reservoir formation, was collected by the Ministry of Environment from 1981 to 1984 (Simpson et al. 1986a). Information presented here was collected from August 1984 to July 1985. Sites used by caribou and grizzlies near the reservoir were identified by tracking radio-collared animals and by recording incidental sightings. Four caribou were followed after flooding, three of which were tracked prior to flooding. Four grizzlies were tracked following flooding, one of which was collared before flooding.

Spring range sites were judged important if individuals remained in one area over a period of time, if several animals used the site or if animals frequently returned to the site. Plots were located at points where there were scats, tracks or other sign or where there were direct sightings. Food plants were identified by examining feeding sites and by direct observation or scat analysis. Many caribou locations in spring were on snow-covered areas. These sites were not considered for plot sampling.

The physical characteristics and vegetation were described for 455 plots. Sampling methods and data coding followed those recommended in Walmsley et al. (1980). We used 2-m radius plots to estimate cover of herbs and shrubs. The density of larger species was estimated by measuring distances to the four nearest individuals from the plot centre. Data sheets were modified from Walmsley et al. (1980) and also included information on lichen abundance, cover, obstruction to movement and occurrence of wildlife sign (Appendix A). Lichen was visually estimated on a scale of 0 (nil) to 4 (> 50% cover) after Bloomfield (1979). Cover was assessed by measuring the distance to points where a person was 50% and 90% obscured. Obstruction was estimated on a scale of 1 (open) to 5 (dense) or by recording the time taken to walk 25 paces. Scats, tracks, feeding and bedding sign in the vicinity of the plots were also recorded. Data from plots, within cedar-hemlock forest, slash and seral stands were used to classify sites into ecological forest plant associations identified for the Nelson Forest District (Appendix A, Utzig et al. 1978).

We made fixed-wing flights weekly from February to June and bi-weekly from July to January. During each flight, we recorded the locations of radio-collared animals and other incidentally sighted animals. Ice conditions on the reservoir, particularly the occurrence of shoreline ice shelves, were recorded. Reservoir crossings by radio-collared or other animals were recorded. In March, caribou groups were censused by searching the additional parkland ranges not normally overflown during routine radio location flights. Cows, bulls and calves were classified during later helicopter flights.

SECTION 1 - CARIBOU

RESULTS

Reservoir Impacts on Movements

The reservoir, which was filled between October and December of 1983, was only 2 km across at the widest point and did not obstruct the movement of caribou across the valley (Figure 1-1). It was completely cleared, prior to flooding, and remaining shoreline debris, which might have obstructed swimming animals, was removed and burned. We recorded six crossings by radio-collared animals from 1981 to 1983, prior to filling, and eight crossings after filling. Two radio-collared animals that regularly crossed the river continued to cross after flooding. Most crossings of the reservoir occurred in April or late fall (Table 1-1). No caribou are known to have died from attempting to cross the reservoir.

In 1985, ice formed in early January and six deer and one moose fell through and drowned. The reservoir was completely frozen from the Revelstoke Dam to Ruddock Creek on February 4. Tracks indicated that many deer, moose and coyotes crossed on the ice in February and March. By February 13, open water appeared in the narrower portions of the reservoir north of Downie Creek. Shoreline ice shelves persisted north of Downie Creek until March 15. Ice broke up in early April and was gone by April 16.

Winter weather conditions in 1984-85 were typical of the previous 5 years (Table 1-2). Mean temperatures were below freezing from December to February and slightly above freezing in November and March. The number of days with below freezing temperatures (freezing degree-days), and the potential for ice to form, was greatest in December and January.

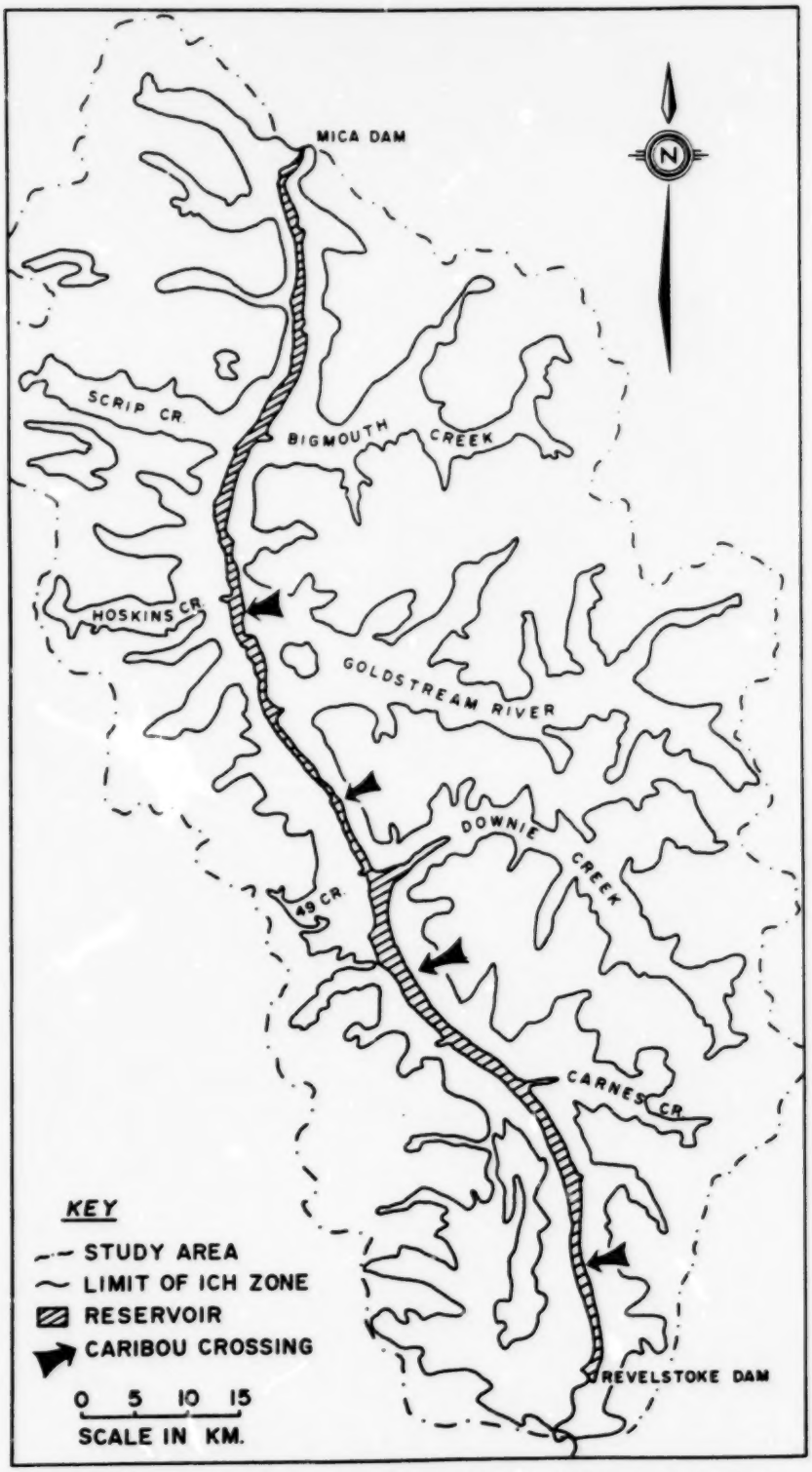

FIGURE I-1. The study area showing the Interior Cedar Hemlock Zone and the flooded area.

Table 1-1. Timing of reservoir crossings of radio-collared and incidentally sighted caribou, 1981-1985

Date	No. of Crossings
April	7
May	1
June-September	3
October	3
November	4
December	3
January-March	0

Table 1-2. Mean temperatures and freezing degree-days in winter, 1979-1985

		Mean Temp. (°C)			Freezing Deg.-days[a]		
Month	N	1984-85	1979-85	SD	1984-85	1979-85	SD
Nov.	6	0.2	1.4	2.3	0	0	-
Dec.	6	-6.5	-4.5	2.3	201	139	70.4
Jan.	6	-5.1	-4.5	2.8	154	140	87.2
Feb.	6	-4.2	-2.2	1.9	116	61	53.4
Mar.	6	1.0	2.4	1.3	0	0	-
Apr.	6	6.4	6.7	1.5	0	0	-

[a] °C<0 X No. of days

Table 1-3. Spring habitats used by caribou before and after reservoir flooding

Apr.15-June 30 Habitats	% Before flooding		% After flooding	
	radio	incidental	radio	incidental
Cedar-hemlock forest	42	28	30	20
Riparian meadow	0	10a	7	20
Reservoir (cleared)	3	27	-	-
Avalanche path	3	2	16	4
Logging slash	8	16	0	33
Seral forest	0	2	5	0
Spruce-balsam forest	26	4	33	4
Spruce-balsam parkland	18	12	9	18
No. of locations	65	104	57	49

[a] All in the reservoir

Spring Habitat Use

Radio location data showed that caribou moved to their lowest elevations each year in May and November (Fig. 1-2). The reservoir area, which was largely cleared, was used only in spring. Although the reservoir occupied only 2% of the land base in the study area it contained over 80% of the riparian meadow and cleared habitats within the range of collared caribou. Following flooding, caribou continued to use the few available valley bottom meadows but most use was in cedar-hemlock (ICH) and Engelmann spruce-subalpine fir forest (ESSF, Table 1-3). Use of clearcut areas adjacent to the new reservoir remained unexpectedly low whereas use on avalanche paths increased slightly. Avalanche sites used were in early phenological stages adjacent to snow. Sites used within spruce-balsam and seral forest were all snow-covered in spring. Many caribou continued to use snow-covered habitats despite the availability of green vegetation at lower elevations. Parturient cows consistently selected snow-covered sites in spruce-fir forest or parkland for calving. Thirty-one of the 53 spring radio locations, in those habitats, were cows with new calves in June. Green food was not available to cows at high elevations and their fecal nitrogen levels were significantly lower than levels found for other animals feeding at lower elevations (Table 1-4).

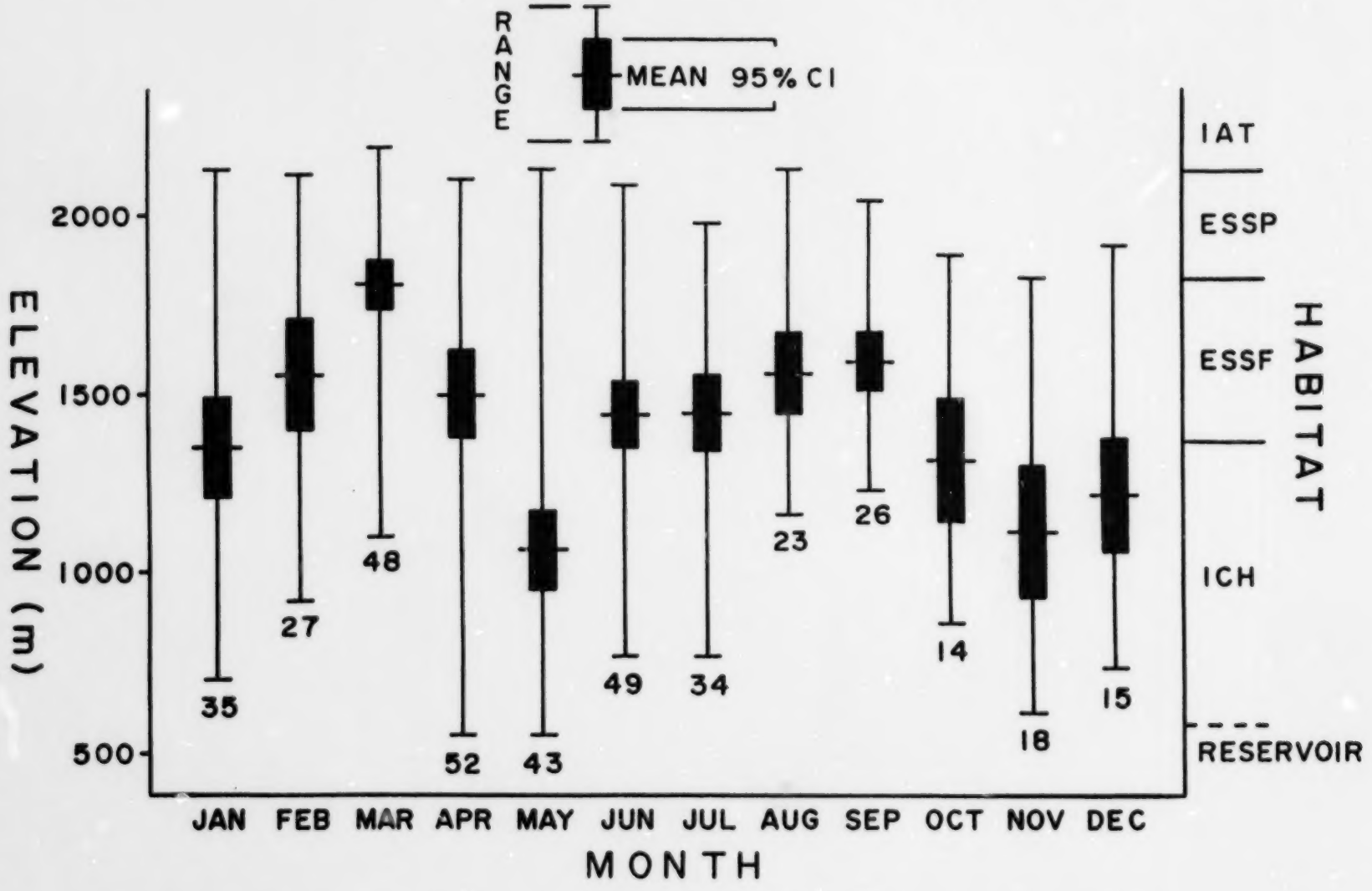

FIGURE I-2. Seasonal use of different habitats and elevations by caribou (from Simpson et al. 1986 a).

Table 1-4. Fecal nitrogen levels in cows with new calves versus other caribou feeding at low elevations in June

	% Fecal Nitrogen		
	N	Mean	SD
Cows with new calves	14	2.37	.36
Other caribou	50	2.87	.63

Anova F = 7.98, P < .006

Observations at 35 spring feeding sites, including five direct sightings of feeding animals, indicated that sedges, grasses and horsetails were commonly used spring foods of caribou (Table 1-5). These plants were most common in riparian meadows, cleared areas, avalanche paths, logging slash and wet areas within cedar-hemlock forest (Table 1-6). Most locations of caribou on snow-free habitats were in cedar-hemlock forest. In addition, twenty-one of 28 plots located at caribou feeding sites within cedar-hemlock forest were on dry, not wet, sites. Other foods such as Vaccinium membranaceum (black huckleberry), Streptopus roseus (rosy twistedstalk) and Gymnocarpium dryopteris (oak fern) were most abundant at these locations (Table 1-6). Caribou were located most often in habitats where food plants were less abundant or in snow-covered areas where green plants were not available at all (Table 1-3).

Predators and Habitat Selection

I compared the spring habitat use of caribou with grizzlies to determine the extent of overlap or exclusiveness. Grizzlies were the only effective predator in the study area during spring. Two small packs of wolves, totalling less than 10 animals, have been seen in the two largest tributaries east of the Columbia. Neither wolves nor their sign have been observed over most of the study area. Grizzlies were found feeding on caribou carcasses twice, in May and June, but I could not determine if the bear had killed or scavenged them. No caribou were known to have been killed by grizzlies, but radio-collared bears did kill two adult and one yearling moose. Grizzlies also killed or scavenged another moose, a goat and three deer. Two kills occurred in seral forest and one at the edge of the reservoir clearing where windfallen trees formed a V-shaped trap. Two of the moose killed had high bone marrow fat (> 70%) and the leg bones were intact on all three suggesting that they

Table 1-5. Food plants used by caribou at 35 spring feeding sites

Species	N
Carex spp. (sedges)	12
Equisetum spp. (horsetails)	11
Streptopus amplexifolius (clasping twistedstalk)	11
Vaccinium membranaceum	9
Grasses (Graminae)	9
Streptopus roseus	8
Gymnocarpium dryopteris	7
Vaccinium ovalifolium (oval-leaved blueberry)	6
Smilacina racemosa (false Solomon's seal)	5
Lichen litter	5
Lysichiton americanum (skunk cabbage)	5
Athyrium filix-femina (lady fern)	4
Epilobium angustifolium (fireweed)	4
Claytonia lanceolata (western springbeauty)	3
Platanthes sp. (rein-orchid)	3
Sorbus sitchensis (Sitka mountain-ash)	3
Juncus spp. (rushes)	3
Aralia nudicaulis (wild sarsaparilla)	2
Disporum hookeri (Hooker's fairybells)	2
Erythronium grandiflorum (glacier lily)	2

Table 1-6. Importance values (% occurrence + % cover) of caribou spring foods in different habitat types

	ICH wet	ICH dry	Ripar meadow	Aval path	Slash	Seral forest	Cleared
No. of plots	89	130	7	67	105	36	12
Carex spp.	46	.8	165	33	32	14	76
Equisetum arvense	39	5	88	33	48	17	87
Grasses	41	7	79	78	42	31	136
Streptopus amplex.	44	23	44	36	25	9	0
Sub-total	170	36	376	180	147	71	299
Vaccinium membr.	12	62	0	0	30	6	0
Streptopus ros.	48	51	0	70	17	16	0
Gymnocarpium dry.	82	91	30	33	59	19	18
Sub-total	142	204	30	103	106	41	18
Totals	312	240	406	283	253	112	317

Table 1-7. Habitats used by radio-collared grizzly bears in spring 1981 - 1985

Habitats (Apr.-June)	% of Location (N=153)
Cedar-hemlock forest	31
Riparian meadow	4
Reservoir	1
Avalanche path	38
Logging slash	1
Seral forest	9
Spruce-balsam forest	4
Spruce-balsam parkland	8
Other	4

were not in poor condition or crippled. One was killed in a dense stand of second growth forest and another on a road adjacent to a 2-m cut bank. In the first case, the moose was forced by windfalls to run past the bear, whereas in the other two, the bears probably surprised the moose at close range. Two of the deer carcasses were found in seral and one in mature forest. The goat was killed by a bear that positioned himself above a trail between a feeding site and cliff escape terrain. The goat was cut off by the bear while attempting to follow others to the cliff (R. Bonar, pers. comm.).

Cedar-hemlock forest and avalanche paths were the two primary habitats used by grizzlies in spring (Table 1-7). Thirty-six of 55 plots, at forested sites used by grizzlies, were on lower slopes in wet cedar-hemlock forest, the type least used by caribou. Caribou used north and east aspects while grizzlies were found on south and west aspects (Table 1-8). Caribou and grizzly use seldom occurred on the same site at the same time although there was some overlap in habitat types used. Despite the relative abundance of caribou foods in logging slash and infrequent use by grizzlies, caribou seldom used them (Table 1-3).

Characteristics of Spring Habitat

Other factors appeared important in influencing caribou use of different habitats. Caribou chose areas where obstruction to movement from slash debris or vegetation was lower (Table 1-9) and where sight distances around the area were greater (Table 1-10). Riparian meadows offered no obstruction and the longest sight distances of any habitat. Snow cover also provided excellent mobility and longer sight distances since ground vegetation was flattened

under compacted snow. Sites used by caribou within wet cedar-hemlock forest and avalanche paths, the areas most used by grizzlies, had lower obstruction values than randomly located sites within the same type (Kruskal-Wallis test, $P < .02$, Table 1-11). Sight distances did not differ greatly between caribou, grizzly and random sites within the same habitat type.

Population Structure and Mortality

Three radio-collared cows continued the tradition of moving to snow-covered forested areas above 1230 m (4000 ft.) for calving in late May of 1984 and 1985 (Simpson et al. 1986a). All three had calves in 1985 and all calves survived until mid-June or July when last seen. The 1984 calf cohort was the first to be influenced by the loss of spring range in the reservoir. Calf recruitment, censused in March 1985, was down slightly but not significantly from previous years (Table 1-12). The percentage of calves may have been reduced by the unusually large proportion of bulls in the count. The calf/cow ratio of 44:100 was also slightly lower than 53:100 found in previous years, however.

Mortality from legal hunting remained low with one animal taken in 1984 and one in 1985. One illegally killed animal was found in a drainage closed to hunting in October and one of four remaining radio-collared animals was killed in a highway collision in November 1985. Annual mortality of radio-collared adults averaged 19% (4/21 animal-years) and accidents were the only cause. Nine animals were transplanted to an area south of Revelstoke during the winter of 1984-85 and six were radio-collared. Three of the six died within the year, two killed in an avalanche in March and one killed or scavenged by a bear in June.

Table 1-8. Spring use of different aspects by radio-collared grizzly and caribou

1981-85 Apr.-June	No. of Observ.	Aspect (% of Locations)							
		SE	S	SW	W	NW	N	NE	E
Caribou	125	6	10	6	9	8	15	18	27
Grizzly	168	9	22	27	16	1	4	16	5

Table 1-9. Obstruction from vegetation or slash on plots located at sites used by caribou and grizzly bear

	No. of Observ.	Obstruction (% of plots)				
		open	low brush	high brush	thick	tangle
Caribou	71	38	45	16	1	0
Grizzly	125	7	30	46	16	2
Random	232	17	43	27	12	2

X^2 test, P <.001

Table 1-10. Mean distances required to conceal a man at caribou, grizzly and other sites

	50% Cover (m)			90% Cover (m)		
	N	Mean	SD	N	Mean	SD
Caribou	71	27	24	68	33	20
Grizzly	124	16	15	121	22	11
Random	228	25	18	222	34	18

Table 1-11. Obstruction and sight distances at sites used by caribou compared to other sites within the same type

Habitat	Caribou sites				Grizzly and Random			
	N	Obstr	50% cov	90% cov	N	Obstr	50% cov	90% cov
Dry CH	28	1.9	23	33	98	2.1	28	41
Wet CH	10	1.5	17	28	69	2.4	18	27
Avalanche	4	2.0	18	26	61	3.2	12	19
Slash	13	2.5	20	27	79	2.3	17	27

Table 1-12. Caribou sex and age classifications before and after reservoir completion

March - May Counts		Male	Female	Calf	Total	Unidentified
Before (1981-84)	N	206	221	118	545	74
	%	38	40	22	100	
After (1985)	N	99	75	33	207	32
	%	48	36	16	100	

DISCUSSION

Movements Across the Reservoir

The impact of the reservoir on the movements of caribou has clearly been minimal. Several important factors must be considered before attempting to generalize from this result. First, the new lake was relatively narrow and shoreline debris, which may have obstructed swimming animals, was cleared and burned. Caribou are known to be capable of swimming much greater distances across natural lakes in other areas (Klein 1980). Ice was present on the reservoir for only 3 to 4 months and caribou did not traditionally cross during that period. Other ungulates, which attempted crossings when the ice was unstable, fell through and drowned. Caribou form their largest groups in winter (Simpson et al. 1986a). A single crossing attempt, during unstable ice conditions, could easily result in the loss of 20 - 30 animals. Although it is considered unlikely, given the historical weather patterns in the area, ice could form earlier or remain later and directly affect caribou during their traditional crossing periods. Alternately, unnatural disturbances on winter ranges could cause caribou to cross the reservoir during dangerous periods. Further monitoring is advised to better define ice conditions on the lake and ensure that potentially dangerous changes in movement patterns do not occur.

Spring Habitat Use

Evidence presented on the availability of food in habitats used by caribou clearly suggested that finding food was not the prime requisite of habitat selection in spring. The strongest evidence supporting this conclusion is the sacrifice of protein-rich foods during calving when cows have the highest metabolic demand for protein to support milk production (White et al. 1981). When food supplies are deficient the materials required to produce milk must come from the body of the mother. Fat reserves in female caribou reached their lowest point in June or July and marrow fat, the final reserve, was over 50% mobilized in many females (Dauphine 1976). The nutritional pressures suffered by cows could be eased significantly simply by moving into valleys where green protein-rich food was abundant.

I believe that avoidance of predators, specifically grizzly bears, was the reason that caribou remained in habitats where they had less food. Results also suggest that caribou were more successful at avoiding predators than deer or moose that used low elevation ranges in winter and spring.

Grizzlies, being omnivorous, were probably opportunistic predators. Their spring distribution was strongly related to the availability of preferred plant foods (Simpson et al. 1986b). Their use of feeding sites was relatively predictable, making it possible for prey species to avoid those habitats. The locations of the three known moose kills were all removed from bear feeding sites. Locating prey may be one of the reasons that grizzlies moved steadily between preferred feeding sites in spring (Simpson et al. 1986; Russell et al. 1979). Dense seral forest or windfalls at the kill sites gave the bears the mobility and cover advantages needed to capture moose. Two of the moose kills and the goat kill suggest that ambush, where escape routes are obstructed or predictable, may be the most successful predation strategy used by grizzlies.

Predator Avoidance and Habitat

Caribou used sites where food was less abundant to avoid predators in spring. They reduced their vulnerability by using areas removed from predators and by using habitats where escape was easier. Use of snow-covered areas on north and east aspects served to separate caribou from grizzlies. In open habitats, predators could be more easily sighted and avenues of escape were unrestricted. When caribou flee from predators they move to open habitats such as frozen lakes (Bergerud 1974). I expected that sites used by caribou in forest, slash or avalanche paths would have greater sight distances than random sites or sites used by grizzlies. The distance needed to conceal a 2-m tall man may not be a good measure to predict the sightability of predators, all of which stood less than 1-m tall. The sites where grizzly kills occurred suggest that dense cover either allowed bears to ambush their prey or restricted the routes of escape. Caribou use of sites with lower obstruction values and greater sight distances suggest that security from predators was an important parameter restricting the use of snow-free habitats.

The natural meadows and cleared portions of the reservoir provided high quality spring range for caribou. The reservoir was the lowest elevation habitat available to caribou in spring and was one of the first areas to green-up. Although grizzlies did use the reservoir, their opportunity to approach caribou was limited in the large cleared areas. I expected greater use of the reservoir by caribou because of the abundant food and security from predators. Intensive human activities and a tradition to use higher elevation sites may have limited its use. Following flooding, the levels of obstruction and cover in logging slash were unacceptable to most caribou, thus accounting for their infrequent use. When caribou did occasionally use habitats frequented by grizzlies, such as avalanche paths, those sites had much lower obstruction values to facilitate escape. Security from predators appeared to be the most important criterion governing habitat selection by caribou in spring.

Impacts of Habitat Losses

The caribou north of Revelstoke were an unusually productive group compared to other populations in southern British Columbia. Census and calf survival figures suggest an increasing population at a time when many other herds were believed declining (Stevenson and Hatler 1985). Bergerud (1974) related population declines to overhunting, resulting from improved access, and to low calf recruitment, due to predation. My observations of high recruitment,

limited predation and low hunter success were consistent with Bergerud's theory. Counts in March 1985 suggested that the increasing trend may have been reversed during 1984. If fewer calves are found again in 1986, it will be indicative of a sudden and substantial change in the productivity of this population coincident with the flooding of the reservoir.

Previous information suggested that the population was smaller and stable or declining slowly (Russell et al. 1975; Keller and Berry 1979). Although somewhat speculative without detailed previous information, I believe that the cleared reservoir may have enhanced caribou productivity from 1980 to 1984. The reservoir provided a large accessible area secure from predators and with abundant food. Use of the reservoir may have reduced adult mortality and improved the spring condition of pregnant cows. Since the condition of cows was directly related to calf viability and milk production, post natal mortalities, which were believed the main cause of calf losses (Simpson et al. 1986a), may have been reduced. Flooding, in October 1983, eliminated both the cleared habitats and traditionally used riparian areas, potentially causing an immediate decline in 1984 calf survival. I did not gather information on the timing of loss in the 1984 cohort, so the causes are not clear. Early calf survival for three radio-collared cows, in 1985, was higher than in three previous years. This suggests that 1984 calf survival may have been a spurious fluctuation unrelated to spring habitat changes. Further information on 1985 recruitment will be required to confirm a decline in productivity and additional data on early calf survival would be required to implicate losses of spring range as the cause.

Mitigative Measures

Whether or not a direct impact on caribou productivity can be demonstrated, there is clearly a need to replace key habitat components lost in the reservoir. Although some may consider spring range and foods to be abundant use of the most productive habitats is restricted by the caribou's need to avoid predators. The greatest loss incurred was within the riparian meadow type. Use of cleared portions of the reservoir showed that caribou will use artificially created open habitats. Vegetation plots showed that production of food plants was high on cleared sites. Logged areas adjacent to the reservoir, if cleared, would provide habitats similar to those used in spring from 1981 to 1983.

Low elevation mature forest sites, which are an important predator avoidance habitat in spring, are also a critical habitat of caribou in early-winter (Simpson et al. 1986a). Most of the reservoir was either cleared or logged before 1981. Forested land in the Columbia valley was probably heavily used by caribou prior to this study. Loss of these forests contributed to the extensive use of cedar-hemlock forests adjacent to the reservoir in early-winter and spring. Habitat protection efforts should emphasize preservation of mature stands near the reservoir. Stands with larger components of snags and overmature trees were preferred because of their favourable snow shelter, windfall and lichen production characteristics. Other species, such as deer and moose, would also benefit from preservation of mature forest habitats near the reservoir.

Identification of Priority Areas

Seral forest was a poor habitat for caribou in all seasons. Plots showed that seral forest provided the least food of any habitat type. Use by predators and potential danger was also greater in seral forests. Caribou may be unwilling even to cross continuous areas of seral forest. Continuous areas of mature forest interconnected with cleared areas will be increasingly important to caribou as logged areas, which are marginal habitats now, regenerate into unusable seral forests. Alternate prey, such as moose and deer, which increase after logging, may increase predator numbers and lead to total avoidance of low elevation habitats by caribou.

Size and locations of clearings could be determined by the size and location of natural meadows occurring in the reservoir prior to clearing. These sites correspond to two caribou crossing areas identified from previous years data (Fig. 1-1). Corridors of mature forest must be maintained between these sites and higher elevation ranges. Draft plans showing two proposed locations of clearings and corridors are given in Figures 1-3 and 1-4. I would place the highest priority on preserving all remaining mature forest within 1 km of the reservoir inside the areas indicated on the maps.

Several criteria were used in selecting these sites. First was the suitability of each site to produce foods used by caribou. Wet areas, which contained some natural clearings prior to logging, produced the most sedge and horsetail. Second, each area should be removed or screened from road access to reduce the potential for disturbance from people. Most sites recommended for clearing are on the west side of the reservoir away from highway access. Third, each site was adjacent to the reservoir or mature forest to provide easy access to caribou. Further, all areas of mature timber bordering the reservoir should also be scrutinized as potential early-winter range for caribou, particularly in crossing areas indicated in Figure 1-1 (Simpson et al. 1986a).

The value of the areas proposed for clearing may be significantly enhanced, without the use of heavy equipment, simply by hand slashing and burning. The objective would be to reduce the obstruction of down material and shrubs and increase sight distances. Particular attention should be given to removing barriers and windfalls between the slash and the forest. Young conifers at spacings greater than 15 m could be left or planted to maintain each area for timber production and inhibit shrub growth. The value of the cleared areas to browsers would be reduced but there are many alternative slash areas that moose and deer could use. Use of the areas by caribou should be monitored by sighting or pellet group count data. If deemed successful, the sites would require clearing of regenerating shrubs at 5- to 10- year intervals and additional sites could be selected for clearing.

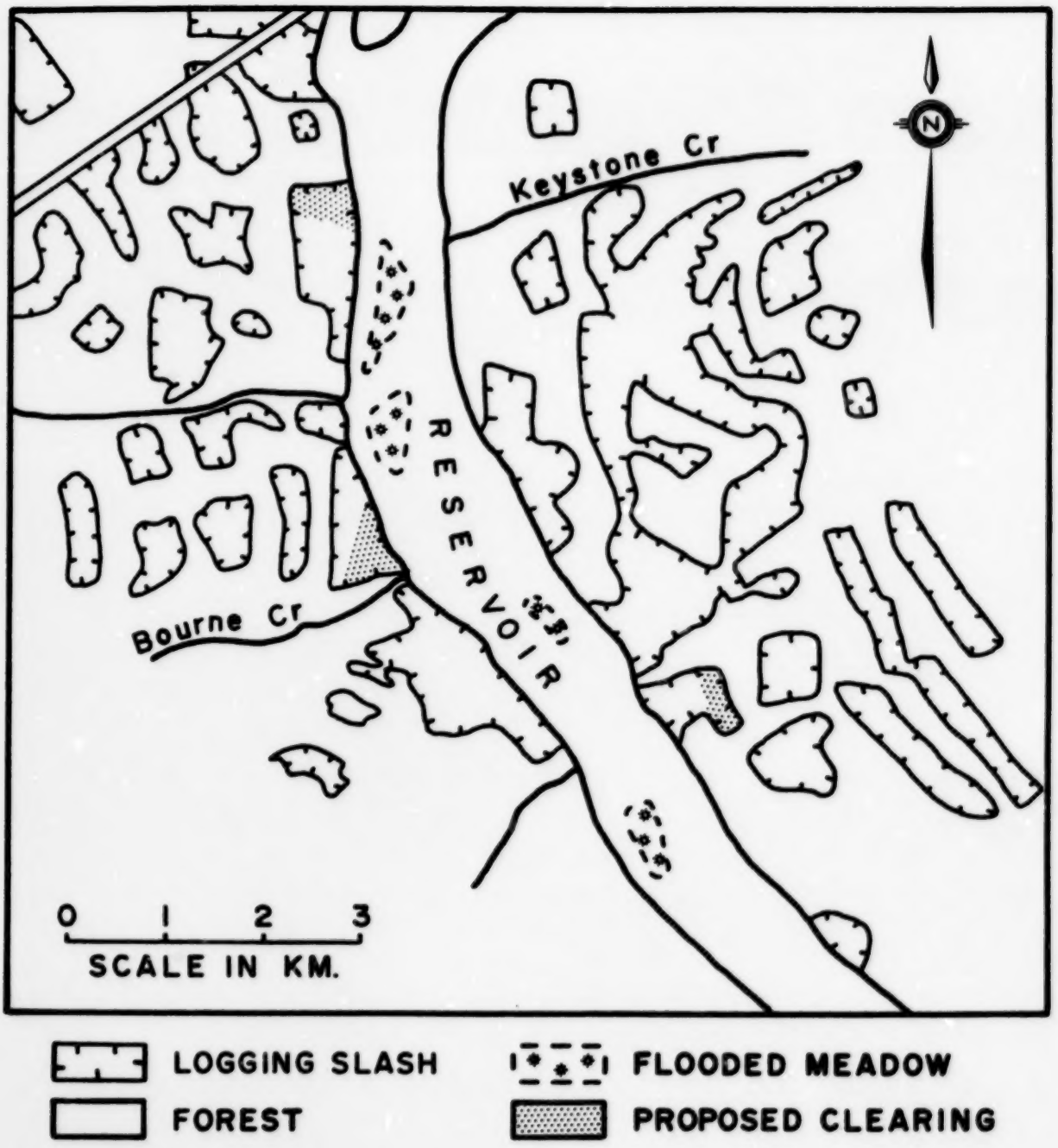

FIGURE I-3. Recommended sites for replacement of caribou spring range, Bourne Creek area.

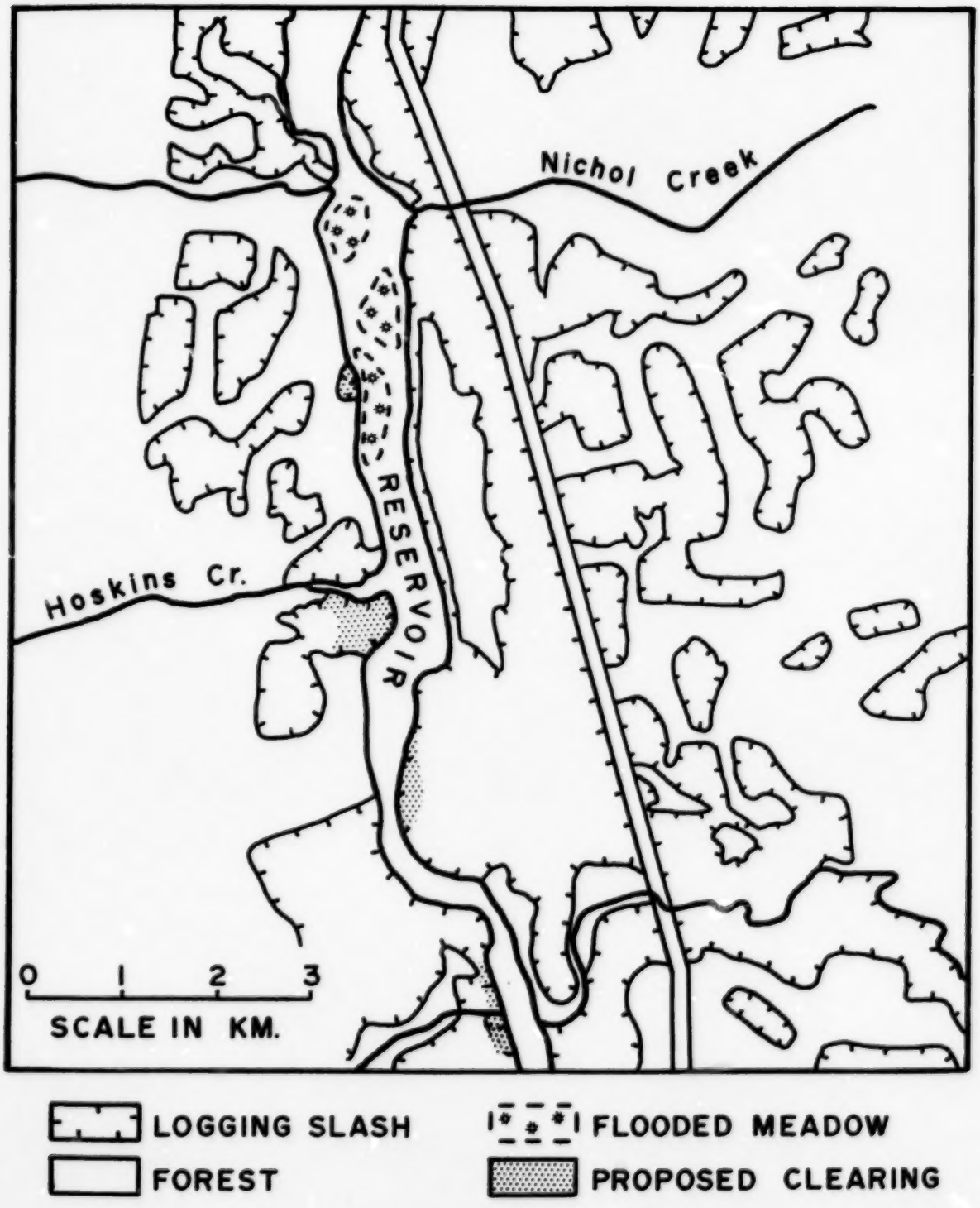

FIGURE I-4. Recommended sites for replacement of caribou spring range, Hoskins Creek area.

SECTION 2 GRIZZLY

RESULTS

Reservoir Impacts on Movements

Prior to flooding grizzlies used the reservoir mainly in spring (Fig 2-1). No collared grizzlies crossed the reservoir following flooding. The single animal which had been collared prior to flooding had used the cleared reservoir in 1981 and 1983 but had only crossed the river in 1981 (Fig 2-2). In 1985, this bear approached the reservoir only once at a formerly used site where he was captured. He immediately returned to a side drainage where he remained for most of the spring season. During the breeding season, in June, he moved 30 km north along the reservoir. Although this was an unusual movement outside his former range, he did not approach the reservoir and there was no indication that he attempted to cross. Three grizzlies, which were collared in 1984 or 1985, consistently used areas adjacent to the reservoir from April to June. The movements of one bear, transplanted into the area in 1985, suggest that grizzlies would cross a river but not the reservoir. For the first month following his release, this bear moved rapidly north then south along the reservoir. He was located 11 times during this period never more than 300 m from the water. Once south of the Revelstoke dam he immediately crossed the river and moved to a drainage 30 km west. Seven grizzlies were captured from 1981 to 1983 within 2 km of the reservoir. Three of the seven crossed the Columbia River within the first year. In contrast, none of the four bears captured or released near the reservoir crossed in 1984-85 although one crossed the river immediately below the reservoir. Three of these animals were tracked only in the spring of 1985.

Spring Habitat Use

Spring habitat use was similar before and after reservoir flooding (Table 2-1). Grizzlies continued to use areas adjacent to the reservoir and virtually all of their daytime use was within forested sites. Avalanche paths, most located in side drainages of the Columbia, continued to be a key feeding habitat. One young male stayed close to the highway during May and early June in 1985. I located five daybeds within 200 m of the road and found the remains of deer at two. Deer were frequently seen along the highway and at least three were reported struck by vehicles. Although this bear remained very close to the road, I never observed him on the highway. Another bear, using the west side of the reservoir, exhibited the same movement pattern along the shore but scat analysis showed that he was not feeding on deer.

Grizzlies using areas near the reservoir fed more frequently on horsetails and clover (Trifolium spp.) than bears using tributary drainages (Table 2-2). Heracleum spp. occurred more commonly in scats found in side drainages. Grasses and sedges were frequently found in scats from both areas, although there was an insignificant trend to higher use in the reservoir area. Other weed species such as Taraxacum spp. and Vicia spp. occurred only in areas near the reservoir. Avalanche lily, which occurred rarely in scats, was also important to grizzlies in spring. I observed digging at all avalanche sites

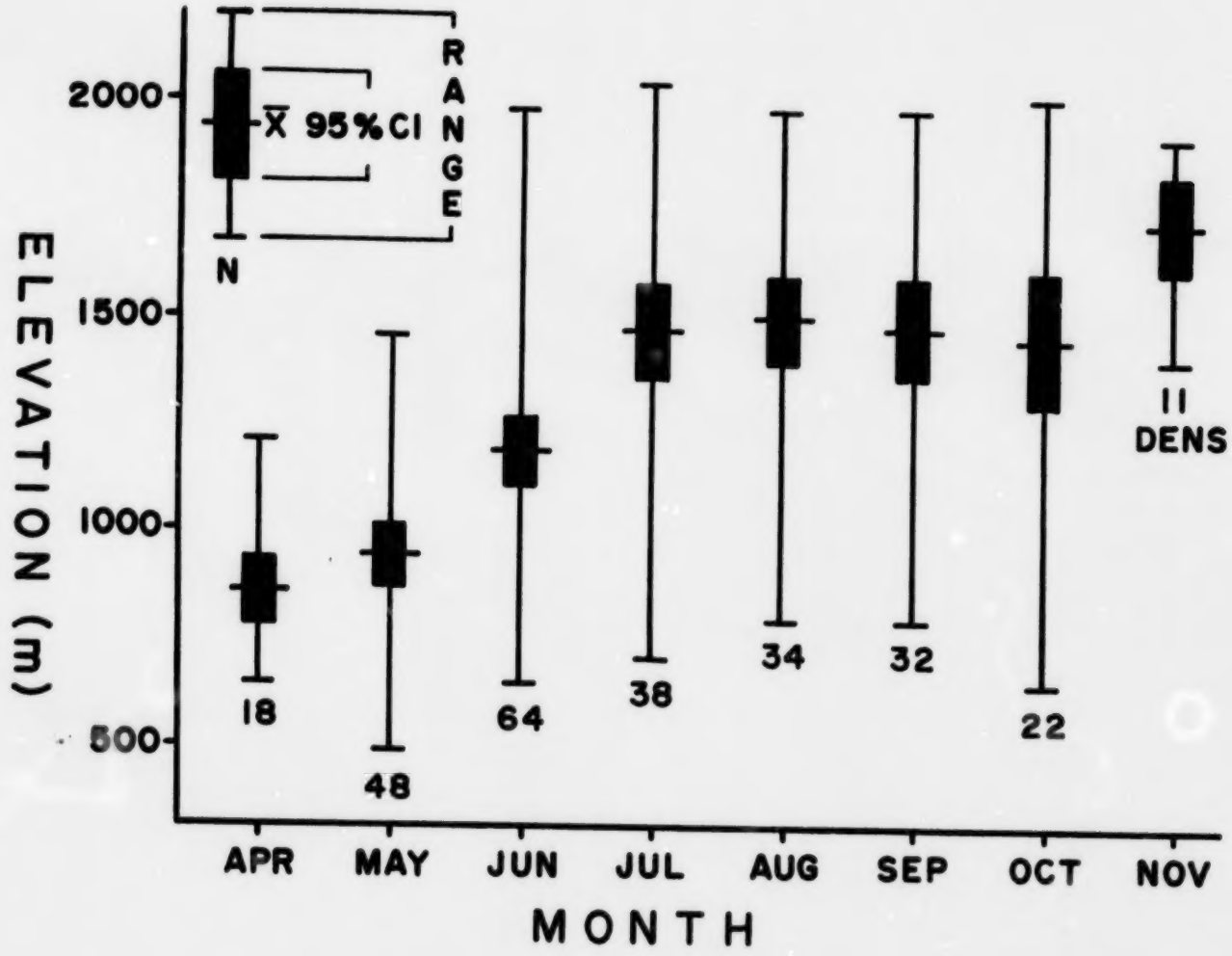

Figure 2-1. Seasonal elevation use by radio collared grizzlies from 1981 to 1985.

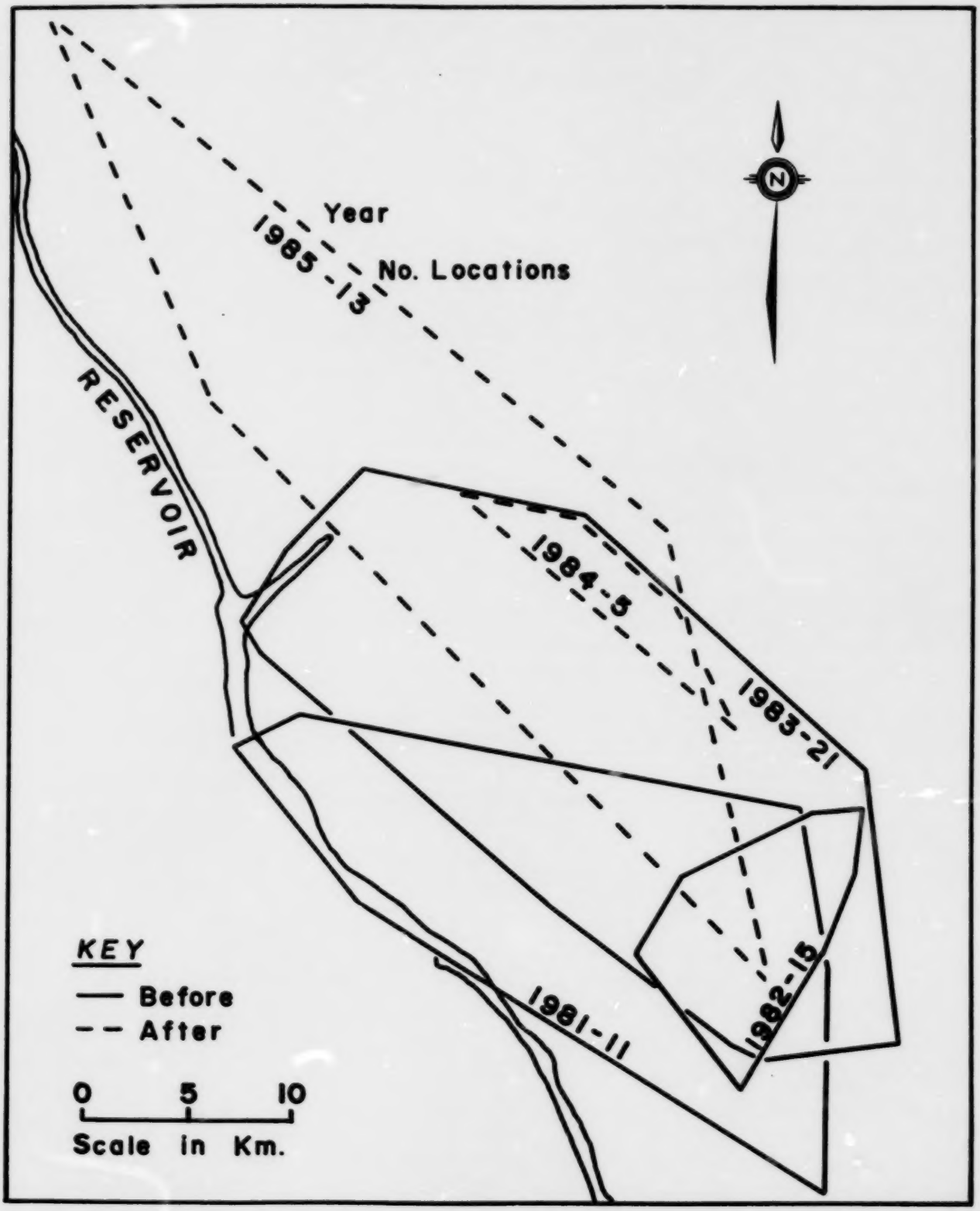

Figure 2-2. Spring ranges of an adult male grizzly before and after reservoir flooding.

Table 2-1. Spring habitats used by grizzlies before and after reservoir flooding

April-June	% Before Flooding		% After Flooding	
	air-radio	incidental	air-radio	incidental
Cedar-hemlock forest	31	42	45	57
Riparian meadow	4	2	6	6
Reservoir	1	7	--	--
Avalanche path	41	26	29	9
Logging slash	1	5	3	7
Seral forest	8	13	12	12
Spruce-fir forest	4	1	2	1
Spruce-fir parkland	10	1	2	0
Other	3	3	2	9
No. of locations	117	169	36	48

used by grizzlies and lilies were always present in digs. Remnants of lily stems and leaves were found suggesting that grizzlies ate the fleshy bulbs.

Disturbance by man increased the occurrence and abundance of several important food plants. Sedges, grasses, horsetails and clover were more common in logged and cleared areas than in forested sites. Cleared road margins and the powerline right-of-way provided particularly abundant sources of some foods (Table 2-3). These man-disturbed habitats compared favourably with naturally disturbed areas such as avalanche paths and riparian meadows.

Radio-collared grizzlies were located in or near the reservoir 36 times prior to flooding and 29 times after flooding. They were sighted in cleared areas, along the road or powerline, only six times during daylight hours and they were never observed in logging slash. The preponderance of sedges, grasses, horsetails and clover in scats collected near the reservoir shows that bears were feeding in open areas. Twelve night locations confirmed that bears did use open areas at night. In contrast, grizzlies were frequently observed on avalanche paths in tributary drainages during the day. Bears were found to be most active in those areas at 1800 h each day (Simpson et al. 1986b).

Table 2-2. Food plants of grizzlies determined from scats collected near the reservoir and in side drainages

Species	Near reservoir		Side drainages	
	N	%	N	%
Grasses	29	53	20	39
Equisetum spp.	36	65	13	25
Carex spp.	28	51	20	39
Heracleum sphondylium	1	2	34	67
Trifolium spp.	20	36	2	4
Ants	7	13	11	22
Odocoileus hemionus	6	11	0	0
Oszmorhiza depauperatau	2	4	2	4
Microtus spp.	1	2	3	6
Erythronium grandiflorum	0	0	2	4
Vicia spp.	2	4	0	0
Taraxacum sp.	2	4	0	0
Betula papyrifera	0	0	2	4
Claytonia lanceolata	0	0	1	2
Alces alces	1	2	0	0
Dendragapus obscurus	1	2	0	0
No. of scats	55		51	

Table 2-3. Abundance (% occurrence + % cover) of important grizzly foods in various habitat types

	Forest	Slash	Cleared	Avalanche	Meadow
Horsetails	24	49	87	11	87
Grasses	24	43	136	78	79
Sedges	33	32	76	33	165
Clover	0	3	86	0	0
Cow parsnip	5	0	0	113	0
Glacier lily	21	0	0	65	0
TOTALS	107	127	385	300	331
No. of plots	219	105	12	67	7

Table 2-4. Characteristics of grizzly spring habitats

	Feeding site			Bed site		
	Mean	SD	N	Mean	SD	N
Canopy % closed	28	19	7	59	28	18
Distance (m) to nearest evergreen	9.0	3.9	7	6.7	2.6	18
50% cover (m)	16	21	59	14	8	20
90% cover (m)	19	10	56	22	12	20
Distance to nearest shrub	3.5	1.3	59	0.6	1.5	20

Characteristics of Spring Habitat

Grizzlies chose distinctly different areas for feeding and bedding. Eighteen bed sites found in 1985 were in forest and two were on avalanche paths. Within forested sites, 11 of the beds found were in the Oplopanax-Athyrium association adjacent to avalanche paths. Only seven spring feeding sites were found in forest and four of those were in the Oplopanax-Athyrium association. Lower canopy closure and greater tree spacing at forested feeding sites allowed more light penetration that promoted the growth of food plants (Table 2-4). Although most feeding sites were on avalanches, cover characteristics were similar to forested bed sites due to the dense ground vegetation (Table 2-4).

Avalanche paths were the principal feeding area for grizzlies but not all avalanches were used. Preferred food plants were absent or rare on low use slides and covers of alder (Alnus viridis ssp. sinuata) and wood fern (Dryopteris assimilis) were greater (Table 2-5). Seventy-five percent of low use slides were classed as mesic or drier while 50% of the high use slides were classed sub-hygric or wetter.

Table 2-5. Plant species on avalanche paths that were used compared to paths not used by grizzlies

	High use (N=59)		Low use (N=8)	
	% Occurrence	% Cover	% Occurrence	% Cover
Cow parsnip	86	31	62	9
Sedges	27	8	12	1
Glacier lily	52	15	38	9
Alder	67	13	75	62
Wood fern	73	6	38	26

DISCUSSION

Movements Across the Reservoir

The evidence presented suggests that the reservoir was a barrier to movement for grizzlies. Unfortunately all of the animals that had regularly crossed the reservoir prior to flooding were either dead or had lost their collars. Without such animals, conclusive proof of the impacts of the reservoir on movements cannot be given. The reasons that bears were unwilling to cross were not clear. The reservoir, at some points, is not much wider than the river and grizzlies are probably capable of swimming the distance easily. It is also possible that bears may adjust to the change and cross more regularly in the future.

Habitat Use

Habitat use was similar before and after reservoir flooding. The trend to higher use in cedar-hemlock and seral forests and lower use on avalanche paths related to my efforts to capture and track more grizzlies close to the reservoir where there were few avalanche paths.

The most important difference between grizzlies near the reservoir and those in side drainages was their use of food plants most common in man-disturbed habitats. Prior to flooding, the reservoir presented a large cleared area where such foods were available. Following flooding the road margins and powerline right-of-way were the only remaining cleared habitats. The necessity of daylight aerial monitoring inadequately represented the bears' use of cleared areas. The frequent proximity of grizzlies to cleared areas and their food habits strongly suggest that clearings were important feeding areas at night. Grizzlies were attracted to the abundant food in cleared habitats.

The road margins were also attractive to deer. Evidence of bears feeding on deer was found near the highway. One bear on the opposite side of the reservoir, where there was no highway, did not feed on deer. Animals being struck on the highway increased the opportunity for grizzlies to find dead or injured animals and may also have attracted bears to the highway.

Potential Impacts

Spring was the only season that grizzlies were found in or near the reservoir. The reservoir was also the most accessible part of the study area because of the highway from Revelstoke to Mica and the boat access that the new lake provided to the west shore. Factors that increased the use by bears of areas adjacent to the reservoir would make them more vulnerable to hunting in spring. The probability of highway collisions and other incidental mortalities would also increase. Evidence from previous years has shown that grizzlies seen by people are considered a threat and are likely to be shot in any season (Simpson et al. 1986b).

The loss of the reservoir area and the feeding habitats it provided were not important to most bears. Only two of ten radio-collared animals used the reservoir extensively prior to flooding. All radio-collared bears used avalanche paths in side drainages in spring. The reservoir could be more

important if slow snow melt on avalanche paths forced bears to use alternative habitats. In 1985, avalanche paths were among the first areas to green-up and there were no restrictions in the choice of snow-free sites available to bears. The failure of grizzlies to cross the reservoir may have resulted in much more extensive use along its shores had snow conditions in side drainages been less favourable.

Behaviour and Vulnerability

The main impact of the reservoir was related, not to losses of feeding habitat, but to shifting the habitat use into areas where bears may be more vulnerable to people. The behaviour of bears partially compensates for these changes. Grizzlies using areas close to the reservoir were more secretive than bears in tributary drainages and appeared to be most active at night. They did use areas in close proximity to human activities provided they had adequate hiding cover. Maintaining a separation between grizzlies and people, at least visually, and preferably geographically, may be the best method to ensure a stable and healthy population of bears in the study area.

Mitigative Measures

There are three general methods I would recommend to enhance the security of grizzlies in the study area. High risk, cleared habitats, particularly along Highway 23, may be made less attractive to bears by seeding them to non-food plants rather than grasses and clover. This would also reduce the risk of collisions for bears and other species. Visual security cover should be maintained between roads and grizzly feeding habitats, particularly in side drainages where bears are more easily sighted. Access planning should be a high priority in portions of some side drainages, which are heavily used by grizzlies in spring. Figure 2-3 shows the locations of several important spring feeding areas for grizzlies based on radio-tracking results.

Important areas typically had a mix of large and small slides interspersed with mature forest and often with swamps or meadows in the valley bottom. High use slides were easily identified by the higher abundances of bear foods and signs of digging. Glacier lily is obvious only for a short time following snow melt, while cow parsnip is most prominent later. High use slides drained large areas giving them a deep snow pack at their base in spring and a continuing supply of moisture both from snow melt and rainfall. Drier slides, which did not have the same catchment area or were better drained, did not support the same food plants. Drier slides had a greater cover of shrubs, particularly alder, and more non-food plants such as wood ferns. Other drainages in the study area that contain good grizzly spring range and currently have limited access are Stitt, French, Louis Lee, Nagle, Soards, Ruddock, Hoskins, Kirbyville, Fissure, Bourne, Park, Big Eddy and Frisby. I recommend that these drainages be given special consideration for grizzly values in future development planning.

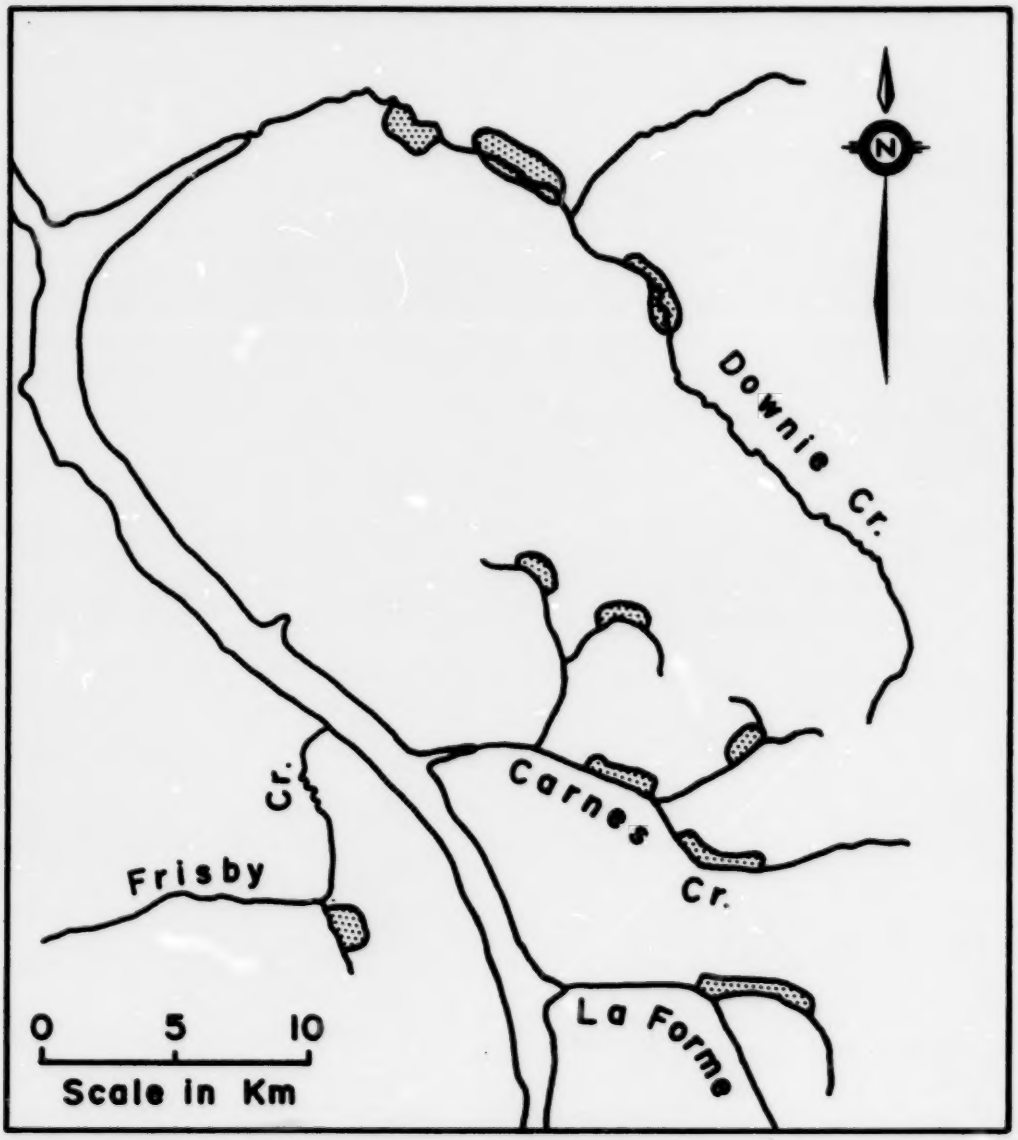

Figure 2-3. Important spring ranges identified by radio collared grizzlies.

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APPENDIX A. Vegetation plot data sheets and coding.

site#_____ creek_____ date_____ samplers_____

site size_____ km2 map grid_____ macro site descr._____

site type_____ access type_____ macro aspect_____

date burned_____ " slope_____

date planted_____ " elev._____

PLOTS

	1	2	3	4	5
m btwn plts					
slope %					
elev. ft.					
aspecto canopy %					
lichen					
soil depth					
meso site					
surface					
moisture					
50% cover					
90% (m)					
obstruction					

SPECIES	D dia/ht	D dia/ht	D dia/ht	D dia/ht	D dia/ht
Trees or shrubs	Distances	diameters	heights		

	1	2	3	4	5
	S T F B	S T F B	S T F B	S T F B	S T F B
SIGN	c r e e	c r e e	c r e e	c r e e	c r e e
	t k d d	t k d d	t k d d	t k d d	t k d d
caribou					
bear	No. scats, tracks, feeding sign, beds				
moose					
deer					
unk					

Appendix A, continued

site#_____ PLOTS- 1 2 3 4 5

date C V P C V P C V P C V P C V P

(Cover, Vigour, Phenological stage)

SPECIES_____

Acer glabrum
Actaea rubra
Alnus viridis ssp.. sinuata
Anaphalis margar.
Apocynum andrasa.
Aralia nudicaulis
Aruncus dioicus
Asarum caudatum
Athyrium filix-f.
Betula papyrifera
Carex spp.
Chimaphila umbel.
Claytonia lanceo.
Clintonia uniflo.
Cornus canadensis
Cornus sericea
Corylus cornuta
Disporum trachyca.
Dryopteris spp.
Epilobium spp.
Equisetum arvense
Equisetum spp.
Erythronium grand.
Ferns
Galium boreale
Goodyera oblongif.
Poaceae
Gymnocarpium dryo.
Heracleum sphondylium
Hieracium albiflo.
Linnaea borealis
Lonicera utahensis
Lonicera involucra.
Lysichiton america.
Mosses
Oplopanax horridus
Osmorhiza depauper.
Platanthera spp.
Pteridium aquilinum
Paxystima myrsini.
Pyrola spp.
Populus tremuloides
Populus balsamifera var. trichocarpa
Picea engelmannii
Ribes spp.
Rosa spp.

Appendix A, continued

site#_____ PLOTS- 1 2 3 4 5

SPECIES	C	V	P	C	V	P	C	V	P	C	V	P	C	V	P
Rubus parviflorus															
Rubus spp.															
Salix spp.															
Sambucus racemosa															
Sedges															
Smilacina racemosa															
Smilacina stellata															
Sorbus sitchensis															
Streptopus amplex.															
Streptopus roseus															
Streptopus strept.															
Taraxacum spp.															
Tiarella unifolia.															
Thuja plicata															
Trifolium spp.															
Tsuga heterophylla															
Vaccinium membran.															
Vaccinium ovalifo.															
Valeriana sitchen.															
Veratrum viride															
Vicia spp.															
Viola spp.															
Other species															

Appendix A, continued

1. Site type.

av = avalanche path
cl = cleared
rm = riparian meadow
se = seral forest
ch = cedar-hemlock forest
rf = riparian forest (CH)
sb = spruce-fir forest
sl = logging slash

2. Plant associations in cedar-hemlock forest or slash.

1 = Paxystima myrsinites - Chimaphila umbellata
2 = Vaccinium membranaceum - Gymnocarpium dryopteris
3 = Corylus cornuta - Aralia nudicaulis
4 = Oplopanax horridus - Athyrium filix-femina
5 = Cornus sericea - Equisetum arvense and
Lysichiton americanum - Sphagnum squarrosum
11-15 = seral forest or logging slash sites within corresponding associations noted in 1-5.
21 = avalanche path
23 = cleared areas - road margins, powerline
24 = riparian meadow
25 = Engelmann spruce - subalpine fir forest

3. Moisture.

1 = Very xeric
2 = Xeric
3 = Sub-xeric
4 = Sub-mesic
5 = Mesic
6 = Sub-hygric
7 = Hygric
8 = Sub-hydric
9 = Hydric

4. Macrosite.

a = Apex
b = Face
c = Upper slope
d = Mid-slope
e = Lower slope
f = Valley
g = Plain

5. Meso site.

a = Crest
b = Upper slope
c = Mid-slope
d = Lower slope
e = Toe
f = Depression
g = Level

6. Aspect.

aaN = 338-022°
bNE = 023-067°
ccE = 068-112°
dSE = 113-157°
eeS = 158-202°
fSW = 203-247°
ggW = 248-292°
hNW = 293-337°

APPENDIX B. The number of plots sampled at caribou grizzly and random sites within each vegetation association.

	Caribou	Grizzly	Random
Interior Cedar-Hemlock forest			
Paxystima-Chimaphila	4	5	33
Vaccinium m.-Gymnocarpium	21	9	36
Corylus-Aralia	3	4	14
Oplopanax-Athyrium	4	31	36
Cornus-Equisetum-Lysichiton	6	6	7
Logging slash and Seral forest			
Paxystima-Chimaphila	1	4	48
Vaccinium m.-Gymnocarpium	3	1	21
Corylus-Aralia	3	3	20
Oplopanax-Athyrium	3	1	16
Cornus-Equisetum-Lysichiton	5	0	12
Avalanche path	4	55	8
Cleared - road, powerline	3	3	6
Riparian Meadow	7	0	0
Spruce-Fir forest (ESSF)	6	3	0
TOTALS	73	125	257

APPENDIX B. Identifying caribou spring range for habitat management.

The presence of food plants used by caribou in spring is not a good indicator of the value of that habitat to caribou because of their avoidance of high risk predation areas. Many spring locations (40%) were in snow covered spruce-balsam forest or parkland where the only food was arboreal lichen. Even on snow-free sites, arboreal lichen cover averaged 25-50% (abundant) at sites used by caribou compared to 5-25% (moderate) at random sites. Snow-free forested sites used by caribou were most frequently located on north or east aspect mid-slopes in the Vaccinium membranaceum - Gymnocarpium dryopteris association. Cedar and hemlock occurred in equal proportions and canopy closure averaged 47%. At randomly located sites the hemlock/cedar ratio was 2/1 and canopy closure averaged 66%. Slopes averaged 16%, soil depth 25cm and moisture was sub-mesic or mesic at forested caribou use sites. As noted earlier, obstruction from ground vegetation or windfalls was minimal and walking through each area was comparatively easy.

Sites not used by caribou were mainly in the Oplopanax horridus - Athyrium filix-femina association. Wetter associations (Cornus - Equisetum and Lysichiton - Sphagnum) were used in areas where open meadows occurred. Several small meadows which were surrounded by dense brush were not used, however, probably because of the potential danger from predators while entering or leaving the meadow. These sites were most heavily used by moose. Wet sites used by caribou were characterized by predominantly spruce/cedar forest cover in a ratio of about 2/1. Canopy closure averaged 15%. These sites were all on lower slopes or valley bottoms with slopes <10%, moisture hygric or wetter and deep soils (x = 44cm).

Following logging, the level of obstruction from slash debris and downed logs was sufficient to preclude use of slashes by caribou. In addition, removal of the forest cover led to drying of each site making them less productive of preferred open habitat foods such as sedges and lilies. Shrub species such as Acer glabrum, Alnus viridis ssp.sinuata, Corylus cornuta, Cornus sericea, Lonicera spp., Salix spp. and Sambucus racemosa , which were sparse but consistently present in the forest, increased rapidly following logging and further obstructed movement and visibility in logging slash. The tendency for blowdown lines to form along cut block boundaries also made access to slash areas difficult and potentially dangerous due to predators. The few sites in logging slash which were used by caribou were wetter and had less slash debris. High moisture increased the growth of food plants and inhibited the growth of many shrubs, thus maintaining more open meadow-like habitats.

I have selected several sites which represent the major spring habitats used by caribou as well as geographically close sites which are not used. All are accessible by road or by boat from the reservoir and could be visited in a single day. These are:

1. Riparian meadow and forest - High use: south of the mouth of Hoskins Creek, elevation 1900 ft.
   - Low use: 1 km north-east of the mouth of Hoskins Creek, small pond and meadow, elevation 1950 ft.

2. Cedar-hemlock forest - High use: leave strip 1 km north of the mouth of Hoskins Creek, elevation 2600 ft.
   - Low use : leave strip along Highway 23 immediately north of the Downie Creek bridge.

3. Logging slash - Used: slash 400 m north-west of the mouth of Bourne Creek, elevation 2000 ft.
   - Not used: slash/burn between Bourne and Park Creeks, elevations 2000-2500 ft.

4. Seral forest - Rarely used: along Highway 23 from Carnes Creek to Mars Creek.

APPENDIX C. Identifying grizzly bear spring range for habitat management.

Quality grizzly spring ranges were most easily identified by the presence of spring foods especially sedges, grasses, horsetails, Heracleum sphondylium and Erythronium grandiflorum. Avalanche paths were the most frequently used feeding habitat and the signs of use, particularly digging, were obvious. Grizzly beds dug out at the base of large conifers could often be found in the forest adjacent to feeding sites. Scats were infrequently found on feeding sites, perhaps because of the dense ground vegetation, but many were found at the bed sites. All sites were on lower slopes and most (69%) were on south or west aspects. Slopes averaged 30% and soil depth 24cm. Forest cover adjacent to avalanche paths was mainly cedar (66%) followed by hemlock (26%) and spruce (8%). Most forested sites (56%) were in the Oplopanax horridus - Athyrium filix-femina association with canopy closure averaging 57%.

Other important habitats were sedge meadows and riparian forest. These sites fell within the Cornus sericea - Equisetum arvense and Lysichiton americanum - Sphagnum squarrosum associations. Grizzlies using such areas left little sign of their presence. Scats were found infrequently and bears moved to dry ground to bed, generally in nearby forested areas. Scats showed that horsetail and sedge were the main plants eaten. These sites were heavily used by moose and I suspected that much of the time spent by bears in these areas was related to stalking prey rather than feeding on vegetation. Tree species were again, mostly cedar (55%) followed by spruce (26%) with some hemlock (17%) and canopy closure averaged 29%. Slopes averaged 10% and most sites had standing or running water throughout (subhygric-hydric). Sites located by bears all occurred on lower slopes or valleys but similar habitats were found on mid- and upper- slopes where benches held water. Running water appeared to promote early snow clearing on the sites.

Two sites, both accessible by road, are representative of quality grizzly spring range. These are:

1. Avalanche / CH forest - two slides and adjacent forest on the north side of Carnes Creek within 1km west of the junction with MacKinnon Creek.

2. Riparian forest - wet bench below the Gregson forest road south of Keystone Creek. Map co-ordinates 5698.0 N 399.6 E. Elevation 2600 ft.

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Wildlife Working Reports should not be cited because of the preliminary nature of the data they contain

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WR-24 Impacts of a hydro-electric reservoir on populations of caribou and grizzly bear in southern British Columbia. K. Simpson. February 1987. 40pp.

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